

Abstract:

Damage tolerance testing development was required to help qualify a new spin forming dome fabrication process for the Ares 1 program at Marshall Space Flight Center (MSFC). One challenge of the testing was due to the compound curvature of the dome. The testing was developed on a sub-scale dome with a diameter of approximately 40 inches. The simulated service testing performed was based on the EQTP1102 Rev L "2195 Aluminum Lot Acceptance Simulated Service Test and Analysis Procedure" generated by Lockheed Martin for the Space Shuttle External Fuel Tank. This testing is performed on a specimen with an induced flaw of elliptical shape generated by Electrical Discharge Machining (EDM) and subsequent fatigue cycling for crack propagation to a predetermined length and depth. The specimen is then loaded in tension at a constant rate of displacement at room temperature until fracture occurs while recording load and strain. An identical specimen with a similar flaw is then proof tested at room temperature to imminent failure based on the critical offset strain achieved by the previous fracture test. If the specimen survives the proof, it is then subjected to cryogenic cycling with loads that are a percentage of the proof load performed at room temperature. If all cryogenic cycles are successful, the specimen is loaded in tension to failure at the end of the test. This standard was generated for flat plate, so a method of translating this to a specimen of compound curvature was required. This was accomplished by fabricating a fixture that maintained the curvature of the specimen rigidly with the exception of approximately one-half inch in the center of the specimen containing the induced flaw. This in conjunction with placing the center of the specimen in the center of the load train allowed for successful testing with a minimal amount of bending introduced into the system. Stress corrosion cracking (SCC) tests were performed using the typical double beam assembly and with 4-point loaded specimens under alternate immersion conditions in a 3.5% NaCl environment for 90 days. In addition, experiments were conducted to determine the threshold stress intensity factor for SCC ($K_{I_{SCC}}$) of Al-Li 2195 which to our knowledge has not been determined previously. The successful simulated service and stress corrosion testing helped to provide confidence to continue to Ares 1 scale dome fabrication.

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